NIH/NSF Fall 2004 Workshop onVisualization Research Challenges
Position Paper
September 22-23, 2004

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In the growing field of information visualization, I would like to highlight two challenges: evaluation, and achieving universal access.

1) Producing valuable evaluations

If the goal of visualization is insight, not graphics, then we need to document, understand and eventually predict the insight generating process. The reports of controlled experiments are helpful to understand some of the potential and limitations of our tools, but we need to consider other evaluation approaches that take into account the long exploratory nature of users' complex tasks, or the long term benefits of awareness. We need better metrics and benchmarks to compare tools. We also need to document successful adoptions and demonstrated utility. Interactive visualization cannot be evaluated with any simple set of numerical metrics.

As the field of information visualization matures, the tools and ideas described in our research publications are slowly reaching users. Information visualization is moving out of research laboratories with a growing number of commercial products, additions to statistical packages, and commercial development environments. The general public is being exposed to visualizations with SmartMoney financial maps, or the HiveGroup' Peet's Coffee selector. Citizens can find health or voting history information with interactive maps and view real-time highway traffic information. Nevertheless we believe that this modest pace of adoption is hindered by our field's inability to adequately evaluate the benefits of the technology, and guide potential adopters toward successful applications.

2) Achieving universal usability to promote widespread acceptance

The discovery of complex phenomena has been a strong motivation for the use of visualization, but more techniques and tools are now aimed at the general public. Making visualization tools accessible to diverse users regardless of their background, technical disadvantages, or personal disabilities ***is necessary when the tool is to be used by the public***, but it remains a huge challenge. Researchers work with high-end computers but they need to address the range of devices and network speeds available in people's homes and businesses. Special algorithms are needed to guarantee rapid downloads and adequate interaction Visually impaired users may need to use automatically generated text-based alternatives to the visual display. Encouraging results have been found with the sonification of simple graphs, scattergrams, and tables. Spatial sound might help sonify

more complex data representations. High resolution tactile displays are appearing and may be appropriate in certain cases. Specific techniques will be needed to address the needs of novice users, older adults or users with low cognitive abilities who are simply overwhelmed by the complexity of displays that seem trivial to designers, and multi-layer interfaces may assist users find the level of complexity which is right for them.

3) Integrated Tools
Many other challenges need to be addressed to create tools that are truly usable and adapted to the discovery and decision making processes

- Data preparation and import

Researchers have learned that deciding on how to organize input data to achieve a desired result often takes more thoughts than expected. Then getting data into the correct format, data cleansing, coping with missing and uncertain data can be extremely burdensome tasks for which new tools are needed.

- Combine visual representations with textual labels

Visual representations are potent, but meaning textual labels have an important role. Labels should be visible without overwhelming the display or confusing users. Mapmakers have long wrestled with this problem for static maps but we need better tools for interactive presentations

- Integrate data mining

Information visualization and data mining originated from two separate lines of research. Information visualization researchers believe in the importance of letting users' visual system lead them to hypothesis making, while data mining researchers believe that statistical algorithms and machine learning can be relied on to find interesting patterns. Researchers have started to combine those two approaches (Fayyad and Grinstein, 2001) but we are far from a smooth integration.

- Collaborate with others

Discovery is a complex process that depends on knowing what to look for, verifying assumptions by collaboration with others, noticing anomalies, and convincing others of the significance of a finding. Support for social processes is critical to information visualization.

- View large volumes of data

A general challenge to information visualization is the handling of larger volume of data. Many innovative prototypes can only deal with a few thousand items, or have difficulties maintaining real time interactivity when dealing with larger numbers of items. The rare interactive visualizations showing millions of items demonstrate that information visualization is not yet close to reaching the limits of human visual abilities, and user-controlled aggregation mechanisms need to push the envelope even further.

- More specifically, novel techniques are particularly needed for interactive graph visualization (not to be confused with graph layout). Multiple dimensional analyses also remain a big challenge despite the development already of many useful techniques. Knowing where to start exploring is a challenge. Supporting users' discovery process with adequate history keeping mechanisms is still very limited.